Big Rapids Dam Removal

Big Rapids, MI

"The earth does not belong to man; man belongs to the earth."

Chief Seattle 1854

Great Lakes Fishery Trust

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Introduction

It's not often that a state's environmental agencies and a municipal government allow a contractor to splash around in a sensitive river with heavy construction equipment. But such is the story of the Big Rapids Dam removal project on the Muskegon River—one of Michigan's most significant environmental restoration projects.

This booklet tells the story of the Big Rapids dam removal project in Big Rapids, MI. Contractors removed a dam remnant from the Muskegon River there in the summer of 2000 and completed the remainder of the project in 2001. The Muskegon is one of Michigan's largest rivers, and the Big Rapids dam passed an average flow of almost 9,000 gallons of water each second. Big Rapids officials and the Michigan Department of Natural Resources' (MDNR) Fisheries Division conceived the project in July, 1994.

This landmark project evolved over six years of cooperation among City of Big Rapids officials, MDNR Fisheries Division, other state regulators and a number of environmental groups. For Big Rapids, it was an important undertaking because it restored a safe, navigable river to local citizens and visitors.

> ***"The earth does not belong to man; man belongs to the earth."***
>
> ***Chief Seattle 1854***

The Big Rapids Dam remnant before removal.

The Big Rapids Dam removal project is also predicted to have a powerful effect on the ecosystem of the Muskegon River. In his poignant 1854 letter to the United States government[1], often hailed as the most eloquent environmental treatise ever written, Chief Seattle said *"The earth does not belong to man; man belongs to the earth."* For fish, wildlife and the river's ecosystem this project heralds a release of the river back to the "earth"—and away from man's many attempts to harness the river for his own needs.

Purpose

If you are considering removing a dam in your community, we hope that sharing Big Rapids' story will assist you in the process. You will likely face similar concerns as Big Rapids did before your project becomes a reality. You will learn how Big Rapids successfully dealt with issues such as funding; community involvement; engineering; construction; and regulatory and environmental concerns. You will doubtless find some good ideas for your project, and also benefit from Big Rapids' experience by reading the *Lessons Learned* section of this booklet.

This aerial photo was taken in October 2000 after the dam was removed. The yellow dashed line in the upper portion of the photo shows the dam remnant's location, while the lower dashed line shows the cofferdam that formed the sediment trap. The area between the two lines is where sediment settled while the dam was removed.

The Big Rapids Dam's History

Before 1834 Big Rapids was known as the Village of Leonard. The name change recognized the active Village's most prominent natural feature—the big rapids in the Muskegon River.

The area was home to many sawmills and, with the Muskegon River's help, Big Rapids soon became a bustling lumber town. A dam constructed of wooden cribs filled with large field stones was built across the Muskegon River in 1866 to raise the water level so logs could float directly to the sawmills. It was not unusual for logs to completely blanket the river during the logging season.

The 1866 rock crib dam survived until 1912 when a flood breached it. At that time, dams were converting many rivers into hydroelectric power generators, and so, too, was the fate of the Muskegon River. A new, 17-foot-high concrete dam was built over the failed rock crib dam in 1914 and it soon began generating power. It operated until 1955 when Consumers Power Company and its partners de-activated it. In 1966 Big Rapids officials deemed the dam unsafe and contracted to have it removed. Unfortunately the demolition contractor hired to remove the Big Rapids Dam went bankrupt before finishing the project, leaving an ugly, five-foot-high foundation remnant in the Muskegon River.

Even worse, when the contractor demolished the upper portion of the Big Rapids Dam, a massive amount of mostly-sand sediment was released from behind the dam and deposited itself for miles downstream over the next several years. Much of the sand from the 1966 project settled six miles downstream in the bottom of Rogers Pond (The Rogers Dam's impoundment in the Muskegon River). Local lore has it that a gravel pit located upstream of the Big Rapids Dam washed sand from its mined gravel deposits into the Muskegon River. This sand eventually settled into the impoundment behind the Big Rapids Dam, and much of it mobilized during the botched 1966 dam removal attempt. According to downstream property owners, the sediment from the 1966 dam removal effort filled every fishing hole between Big Rapids and Rogers Pond and created many new sandbars. The sandbars altered the river's flow patterns and led to the formation of ice jams and resultant flooding in the winters following 1966. Big Rapids bought the dam remnant from Consumers Power for $6,000 in 1976. Since 1966, the dam remnant served Big Rapids as both a curiosity and a dangerous nuisance. Canoeists and tubers enjoy the

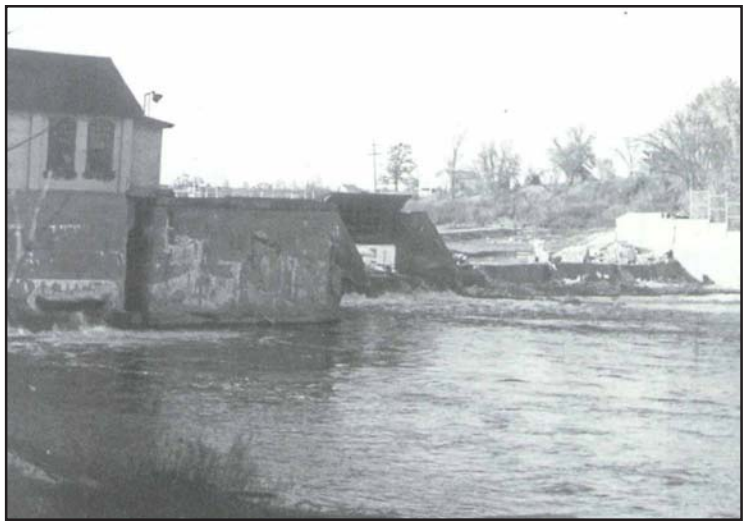
Since 1991, there have been three drowning deaths within 700 feet of the dam remnant.

The botched 1966 dam removal attempt released over 1,000,000 cubic yards of sand sediment downstream. This sediment formed new sand bars that backed up ice in spring, causing flooding to low-lying areas.

Muskegon River. Most recreational users knew of the danger posed by the strong "hydraulic" currents near the dam remnant.

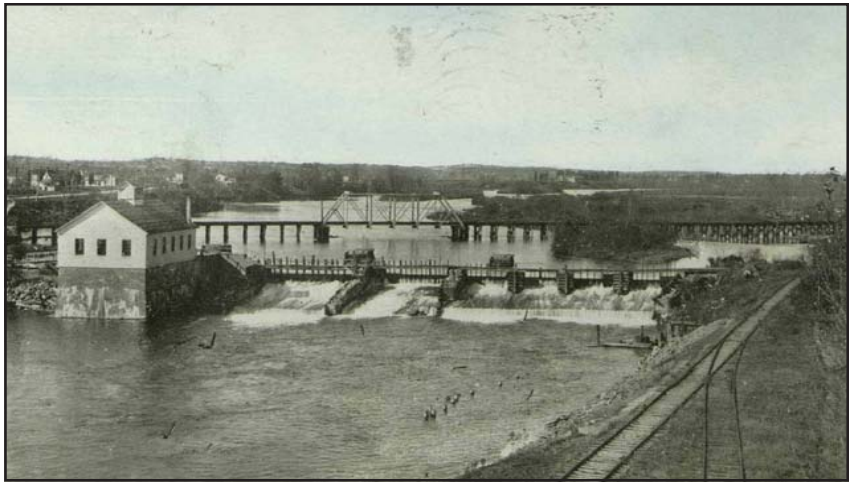
Unfortunately, several incidents there alarmed City officials. Since 1991, there have been three drowning deaths within 700 feet of the dam remnant and at least one dramatic rescue. Frankly, the dam remnant was an unfortunate and dangerous vestige of former days on the Muskegon River and it was a detriment to capitalizing on the Muskegon River as an asset to the community. It was also an impediment to fish trying to swim past it, and a monument to municipal failure in that its 1966 removal attempt was never completed.

With the dam remnant removed, local citizens can see the beauty of the long-submerged big rapids. The river's restoration motivated the community to apply, successfully, for $1,000,000 in private and state grant funds to construct a linear park known as "Riverwalk."



In 1966 Big Rapids attempted to demolish the hydro dam.

The original Big Rapids Dam failed in 1912.



A power company built this dam over the 1866 dam's rubble in 1914.

Project Background

In 1994, City officials conceived the idea to remove the Big Rapids Dam's remnant. In July of that year, the City's water engineers, Grand Rapids (MI)-based Prein&Newhof, met with Big Rapids officials and representatives of MDEQ and MDNR at the site of the dam remnant to propose using its impoundment as a stable source for the raw water intake for the City's water system.

Big Rapids' water intake at that time was located in the Muskegon River behind the City's water treatment plant. This is about 750 feet downstream of the dam remnant. For a variety of reasons, the Muskegon River's water level fluctuated so much there that City officials were concerned about its long-term reliability as a raw water source. The still pool just behind the dam remnant offered a stable, deep-water source. Both Prein&Newhof's engineers and Big Rapids officials wanted to relocate the raw water intake point there.

> ***"Ordinarily, this would be a good strategy, but that dam's coming out."***
>
> ***Bill Gruhn***
>
> ***MDNR Fisheries Biologist***

While presenting concepts for the proposed water intake to MDNR officials, Fisheries Division biologist Bill Gruhn offered, "Ordinarily, this would be a good strategy, but that dam's coming out." Prein&Newhof's President Tom Newhof was on hand for the meeting and questioned what he perceived as a structural engineering analysis by a biologist. He asked Bill upon what information he made his "coming out" claim. Bill clarified his remarks by citing a then-unpublished MDNR report[2] recommending that all non-functional dams on the Muskegon River system should be removed to improve both fish habitat and recreation. Persisting with his curiosity, Newhof quizzed Gruhn "That's noble Bill, but who is going to pay for that?" Without flinching, Gruhn responded that the MDNR would help the City of Big Rapids fund a dam removal project. Big Rapids' City Manager Steve Stilwell longed to remove the dam remnant as it was both an eyesore and a safety hazard. Stilwell decided, on the spot, to take Gruhn's offer of financial assistance.

Subsequently, others from the MDNR Fisheries Division adopted the project and helped shepherd it to reality. MDNR saw this dam removal project as a chance to re-establish a high-gradient stream reach—a very rare occurrence for large Michigan Rivers. The historic "big rapids" were 1.9 miles long and the river's level dropped an average of 12 feet every mile, according to a 1914 engineering study. From MDNR's viewpoint, this dam's removal provided a chance to encourage improvements in the fish community and in fish habitat quality—especially in an urban area such as Big Rapids. The improved and diverse habitat created by removing this artificial obstruction also translates into increased benthic invertebrate production—more fish food!

The City of Big Rapids' #1 goal in implementing this project was to stem the loss of human life in the vicinity of this project. The dam remnant was composed of dangerous snags of fractured concrete, steel, and hydraulic whirlpools. The Muskegon River in Big Rapids is also an attraction for canoeists and tubers, and the dam remnant limited the full use of the river to visitors and residents.

This dam removal project garnered unanimous support and cooperation from Michigan's Departments of Environmental Quality

(MDEQ), Natural Resources Fisheries Division (MDNR) and several privately-funded environmental and outdoors groups.

Experts felt that removing the dam would reduce water temperature, increase dissolved oxygen levels, and improve the habitat not only for fish but also for birds, wildlife and benthic organisms. This project also held the promise of making a treacherous stretch of the Muskegon River navigable again. The dam remnant provided an unnatural obstruction to river flow, limiting or preventing migratory fish movement. It also caused unnatural sedimentation upstream of the dam, obliterating the natural river ecosystem. This was harming fish migratory patterns and natural reproduction.

This photo shows the impoundment of the Muskegon River behind the Big Rapids Dam's remnant. City officials originally wanted to build a new water intake pipe here.

The contractor is just beginning to remove the old dam.

Public Information & Communication

Given the botched attempt to remove the original dam in 1966, the City of Big Rapids knew that formulating and communicating a responsible demolition plan was critical to the success of this project. This project posed serious public relations issues because while City residents saw the benefits of removing the dam, downstream residents feared that the consequences of the project would be destructive. P&N's project manager and City officials had to use out-of-the-ordinary methods to deal with both the capricious flows of the river and the insecurities of the community. These efforts included organizing public meetings, the establishment of a 300-address "stakeholders" database for ongoing communication with residents, and a project website.

> ***"We heard loud and clear from the public that they would not tolerate a repeat of 1966."***
>
> ***Steve Stilwell***
> ***Big Rapids City Manager***

Accordingly, between February 1996 and January 1998, City officials held a series of four public meetings or hearings relating to this project. Over 100 people attended each meeting. The purpose of the meetings was to explain the status of the project and to solicit citizen feedback.

The first such public meeting was held on February 1, 1996 while the project's feasibility study was still in progress. Big Rapids public officials and engineers from Prein&Newhof, the City's consultant, heard plenty from downstream Muskegon River residents who were angry about the river-bottom sand which was released in 1966 when the original dam demolition attempt was botched. "We heard loud and clear from the public that they would not tolerate a repeat of 1966," said Steve Stilwell, Big Rapids' City Manager. "We estimate that over one million cubic yards of sand—enough to build a 555-ft-high mound over a football field—was released downstream when the demolition contractor tried to remove the dam then."

Before the final feasibility study was released, two more public meetings were held on August 12 and 20, 1997 to discuss the study's progress. MDEQ held the final public meeting in January 1998 as part of the public input portion of the project's permit application.

It was with input gained at these meetings that the final feasibility study and sediment management plan was formalized. As a direct result of the open discussion at the public meetings, many local citizens began working with City officials to make this a better project.

During the dam removal project, Big Rapids City Manager Steve Stilwell conducted tours of the project site to keep interested citizens informed as to the project's progress and successes.

The project's web site was also a very effective communication tool. City staff designed and maintained the web site for the duration of the project. Since its inception in June 2000 the site has hosted over 3,000 visitors. The web site's address is:

http://www.ci.big-rapids.mi.us/damremoval/outline.htm

The local newspaper was solidly behind the project, and was a key in reporting information as the project developed.

The unsuccessful 1966 dam removal attempt released over 1,000,000 cubic yards of sand to downstream reaches of the Muskegon River.

SNAP SHOTS

QUESTION OF THE WEEK:

Do you think the city should proceed with the dam removal project?

It's a tad too much to spend to take out the dam. There are better ways to spend the funds on than that.
— Nicole Johnson, Big Rapids

It should be removed. The tubers use it and there have been accidents. From a safety standpoint, taking the dam out makes sense.
— Norman Burhans, Big Rapids

That's a lot of money to spend on that. There must be a way to do it for a lot less.
— Bob Hayner, Mecosta

Nooo. I don't think they should spend that much money on that old dam. They (the city) needs to spend that money on city street improvements and the swimming pool.
— Jamie Tirban, Barryton
Jake Johnson, Remus

Snap Shots is a non-scientific look at various
Pioneer Opinion Page every Monday. Have an opi
Pioneer Hotline (inform

Dam-removal study worth the time

It's been a
look at the
Consumer

years since city officials took a good hard
of removing the remains of the old

Department of Nat-
funds from that
sparked the

Prein and

OUR VIEW

City should pay close attention to dam study

River safety and sedimentation are the primary factors that prompted a study for the removal of the dam.
Residents will meet tonight to review that study on the old Consumers Power dam. The meeting begins at 7 p.m. in Cardinal Hall in the Big Rapids High School.
Threats of lawsuits, disgruntled riverfront property own-

Design & Permitting Process

After the project's unexpected birth that July day in 1994, P&N engineers worked with the City of Big Rapids to make the dam remnant removal project a reality.

Protecting the environment was paramount in all phases of this project, especially in the project development and design phases. Before any other work on this project was done, the sediments trapped behind the Big Rapids Dam were tested for toxicity. The sediments were determined to be "clean" and the project could proceed.

An MDEQ report released in 1998 identified dams as a major environmental threat to river ecosystems. According to this report, dams stop the flow of important nutrients through river systems, form pools of warm water behind them, reduce the amount of dissolved oxygen in rivers, and block access to upstream spawning areas critical to some species.

One of the engineering team's first hurdles included a feasibility study to determine the cost and methods needed to accomplish a successful project. With the help of a $50,000 grant from MDNR, P&N engineers completed the feasibility study in November 1996.

The feasibility study included a 1996 analysis of river-bottom sediments conducted by the United States Geological Survey[3] (USGS). USGS' primary purpose was to study the nature and quantity of those sediments and determine how much of it would potentially mobilize if the dam remnant were removed. USGS scientists determined that as much as 80,000 cubic yards of sediment might mobilize. Since this volume of sediment is enough to cover a football field over 45 feet deep, Prein&Newhof knew it was crucial to conceive a good plan to manage the sediment expected to mobilize or become exposed during the dam removal.

> ***"I'm sure we spent more time and money worrying about sediment management than any other dam removal project that I know of."***
>
> ***James Hegarty, P.E.***
>
> ***Prein&Newhof Project Manager***

At the onset of this project, Prein&Newhof's engineers looked to prior projects for ideas and research. The project team could not find any other dam removal project that had ever seriously considered sediment movement. Prein&Newhof, the City, and the contractors were going to have to come up with a plan themselves. "I called engineers from all over the country trying to learn about successful efforts to manage sediment movement during a dam removal," project manager James Hegarty, P.E. of Prein&Newhof said. "Unfortunately, I learned that most of them just let the sediment go in a controlled drawdown. I'm sure we've spent more time and money worrying about sediment management than any other dam removal project I know of."

The previous attempt to remove the Big Rapids Dam (in 1966) resulted in an uncontrolled release of over 1,000,000 cubic yards of sand downstream of the dam. The political and environmental fallout from that episode demanded that sediment management be a cornerstone of any design.

It was P&N's engineering team's challenge to develop a plan for managing that much sediment and keeping it from flowing

downstream after contractors removed the dam remnant from the Muskegon River. Eventually, engineers settled on a four-step approach.

First, a dredging contractor would launch a hydraulic dredge upstream of the dam remnant and "vacuum" two piles of organic-rich sediment identified by the USGS study on the river bottom just above the dam remnant. It was important to pro-actively dredge at this location as the sediments trapped there were very fine and would "float" when mobilized by the swift river current. The "hole" created by dredging activity eventually would form a new river channel.

Scientists from the United States Geological Survey used ground-penetrating radar to measure the depth and type of sediments trapped behind the dam remnant's impoundment.

Next, a demolition contractor would work with a marine contractor to remove the dam in a way that limited the water level draw-down in the impoundment behind the dam remnant to a maximum of six inches a day. This way, many of the mostly-sand sediments, trapped on the river bottom behind the dam remnant, would not mobilize downstream as the river's surface level lowered. Instead, they would stay behind (sand will settle fairly quickly in river currents) and form new islands or river banks. A great number of timbers left in the river from over 100 years ago assisted greatly in the process of stabilizing sediments.

Then, the design team proposed to use the wide, low-energy area in the river between the dam and a point about 750 feet downstream as a secondary, in-river sediment trap. The contractor could easily clean sediment out of this collection area because a rock dam at the lower end raises the water level and slows down the river's velocity, allowing most sediment to settle to the river bottom. The contractor would clean out the secondary sediment trap, and remove the temporary rock dam shortly thereafter.

Finally, a re-vegetation program to stabilize newly-exposed river banks, islands or mud flats could be initiated to reduce erosion of those areas. Many formerly-inundated logs became exposed, stabilizing the new islands and facilitating the re-vegetation process.

This project eventually budgeted well over $700,000 in measures to assure that a limited amount of sand or other sediment would escape beyond the project site.

The process of gaining permits to remove the dam was not terribly complicated or contentious. Michigan's Department of Environmental Quality (MDEQ) was the lead agency for most of the

permits required for this project. Because MDEQ and MDNR were very much in favor of this project, they were included early and often in the preliminary design process, public meetings, and other project discussions. Permits were applied for in late 1997, and MDEQ hosted a mandatory Public Meeting in January of 1998. Final MDEQ permits were issued in August 1998, with a two-year expiration date to account for the then-uncertain funding process.

Other key elements of the design process included:

- Researching Consumers Energy's engineering files for as-built drawings of the existing dam to assist contractors bidding the demolition work to estimate the cost to do so. While a 1912 drawing was found, it was no better than a conceptual design. It was nonetheless included in the bidding documents with a disclaimer as to its accuracy.
- Flying the project area to acquire aerial photos and digital mapping of the dam and river before demolition. This helped the project team to develop engineering plans, and could also document pre-existing conditions in the event anything went awry in the dam removal process.

Geologists verified the ground-penetrating radar's readings by coring throgh the bottom sediments and comparing results.

- Visiting with officials where other dams had been removed to learn from their experiences. This included meetings in Allegan, Otsego and Petoskey (MI), and also a trip to Stronach (MI) where the project team observed sediment mobilization during a controlled drawdown of the impoundment behind the Stronach Dam on the Pine River.
- Meeting with MDEQ officials involved with the removal of a dam on the Au Sable River in the early 1990s.
- Discussions with marine and demolition contractors to determine the feasibility of removing the dam, cost estimates, and the best dam removal options.
- Requiring the selected contractor to submit a work plan prior to beginning the project. This was done to allow the contractor to propose an alternative to the process defined in the MDEQ permit, and let the City of Big Rapids benefit from any cost-saving ideas envisioned by the contractor in formulating his bid.
- Finding records of the Muskegon River's historical, seasonal flow patterns and providing this information to prospective contractors in the bidding documents.

Construction Process

Big Rapids took bids for the dam removal project on January 13, 2000. It then took several months to finalize contracts and conclude other pre-construction planning. The King Company of Holland, MI, specialists in marine construction and dredging, was the general contractor. King hired Pitsch Companies of Grand Rapids, MI to handle demolition activities. The original contract amount was $1,050,786.

Working in a river can be difficult because the water level can affect the project schedule. The project plans provided to the contractor included MDEQ-generated flow probability scenarios for the Muskegon River at Big Rapids to assist the contractor in his scheduling.

The contractor submitted a work plan and schedule at the outset of the contract. In late May, right about the time the contractor wanted to start work in the Muskegon River, the river level swelled due to late spring rainfall. While this event delayed the start of the project by two weeks, the contractor was able to make up the lost time by utilizing an efficient operation.

In May 2000, the project to remove the dam's remnant from the Muskegon River began in earnest as Pitsch and King crews started their work. King's crews drove steel sheet piles immediately upstream of the old dam's powerhouse foundation on the Muskegon River's west side. This diverted flow away from the area while Pitsch's machinery began the task of breaking up the dam's massive concrete foundation. It wasn't unusual to see exposed timbers left over from the original 1866 dam as Pitsch's equipment began to pick away at the old foundation.

The demolition process began with the contractor driving steel sheet piling upstream of the dam remnant's west side to divert flow over the east side during the demolition process.

Meanwhile, King's crews hydraulically dredged the submerged mounds of organic-laden sediment from just above the old dam. King's dredge pumped sediments and water to a nearby "upland" dewatering and disposal site owned by the City of Big Rapids. This upland site, proposed by King in their work plan as an alternative to the specified disposal site, was closer to the project and worked out very well. This operation worked quite nicely, except the dredge's cutter head would occasionally "hit" timbers left over from the Muskegon River's old logging days that were buried in the sediment.

Pitsch's team demolished the west side of the dam and King finished their sediment dredging operation by mid-July 2000. Next, the contractors began the process of gradually lowering the water level in the impoundment behind the dam remnant. They did this by carefully driving down the previously-installed steel sheet

pilings below the river's surface to divert flow away from the dam's east-side foundation. This allowed the river to run over the lowered sheet piles such that the river dropped an average of a couple inches a day over a two- to three-week period. King's crew eventually completed the drawdown process by simply pulling piles entirely out of the river after they could not be driven any further. Each method successfully effected the controlled draw-down required by the project's MDEQ permit. This process lowered the river surface by about four feet.

The King Company remained busy downstream, building a temporary bridge over the Muskegon River at the secondary sediment trap and placing a crane equipped with a "clam-shell" bucket over the river. The "clam shell" removed sediment mobilized downstream during the draw-down. Another crew planted grass and cottonwood tree "shoots" in newly-exposed, formerly inundated areas upstream from the dam.

Workers attach the polyethylene dredge discharge pipe to the dredge.

The east side of the dam served as both the pre- and post-1966 spillway. After completing the controlled draw-down, the spillway was "high and dry" and the river's full flow hugged the west bank for the first time. Demolishing the remaining portion of the dam was "easy"—the contractor simply placed his equipment on the west end of the former spillway and "peeled" the dam back to the east shore.

It wasn't necessarily that simple, however. Once again, Pitsch's equipment pounded on the concrete structure until it gradually broke into pieces. Boulders, railroad rails, buggy axles, timbers, dirt, and large chunks of concrete and twisted metal were among the many surprises hauled away for disposal. By the end of September 2000, the dam was out of the river!

After the dam was successfully removed, plans called for the contractor to leave his secondary sediment trap in place over the winter to allow additional sand to accumulate in it. In late spring 2001, the contractor moved back on-site to complete the project. Activities included:

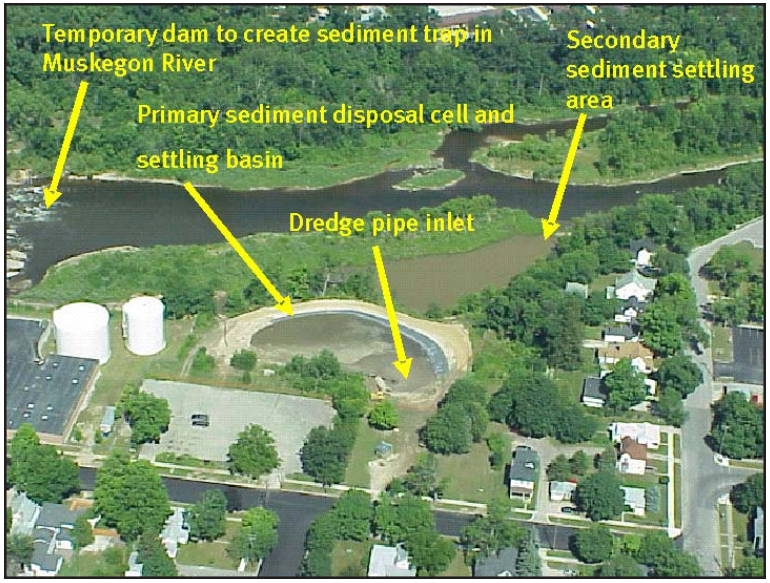
- Re-building a temporary "bridge" into the river at the sediment trap. This bridge allowed the contractor to mobilize a crane fitted with a "clam-shell" bucket to remove sediment from the trap before the temporary "dam" that created it was removed from the river.

- Removing sediment from the river using the clam shell and storing it in the upland sediment disposal area.
- Restoring and grading the sediment disposal area.
- Re-seeding several areas where the river bottom was exposed or new banks had formed.
- Slowly removing the temporary dam that created the secondary sediment trap.
- Removing the wooden foundation of a railroad trestle that became exposed upstream of the dam remnant after the drawdown. A total of 140 wooden pilings were removed from the river's flow channel.
- Cleaning up the west river bank near the dam remnant and beautifying it.

The project was not completely finished until the end of August, 2001. By then, the Muskegon River had dropped almost nine feet in elevation in less than a mile, restoring the "big rapids" in Big Rapids. The following photos document the removal process.

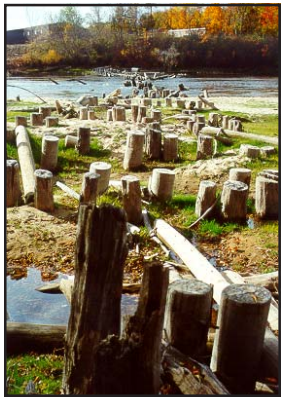
On the left side of this photo, the contractor has diverted the river's flow over the east portion of the dam while demolishing the west portion. The dredging contractor has begun dredging the sand bars located just upstream of he dam remnant.

The contractor created a holding basin and pumped dredged sediments to this city-owned property adjacent to the project site.



Aerial view of the sediment disposal process.

The secondary sediment trap was located about 700 ft downstream of the dam remnant. It collected almost all of the sand that was scoured from the river bottom as its level dropped during the controlled drawdown. The contractor built a temporary bridge into the middle of the river so he could clean out the sediment trap. This photo shows the temporary bridge and the crane equipped with a "clam-shell" bucket. The crane dipped sediment out of the sediment trap and dumped it into the steel box on the bridge. Then, the front-end loader scooped the sediment and took it to an off-site stockpile.



These wooden pilings from an old railroad trestle became exposed in the river upstream of the old dam after the drawdown. The contractor removed them in the summer of 2001.

This aerial photo was taken in late 2000, and it clearly shows the effectiveness of the sediment management plan. You can see the sand sediment that has settled into the river bottom in the sediment trap. The contractor excavated much of it from the river the following year.

The contractor utilized two excavators for the project. One was equipped with a jackhammer attachment, while the other had a hydraulic "claw."

The contractor eventually broke through the dam's structure, allowing them to "peel it back" from the middle of the river toward the bank.

Many vestiges of the old dam were discovered, such as this wooden piling.

After several weeks' work, the west side of the old dam's foundation had been removed. The old sheet pile from the dam remnant and the new sheet pile used to divert flow can be seen in the background.

Once the west side of the dam was taken out, the contractor began to lower the sheet piles used for flow diversion. He was able to control the lowering of the river's level in the impoundment to about 6 inches a day.

Before long, the drawdown was complete, and the river's flow was diverted over to the west side.

This aerial photo was taken just as the contractor began demolition on the dam remnant's east side. You can clearly see the sand sediment beginning to settle into the sediment trap downstream of the old dam. The trail of muddy water leaving the site is not from sediment, but from earth remaining in the old dam's core.

Previously-submerged sand bars like this began to surface shortly after the controlled drawdown began. The timbers in this photo are remnants from Big Rapids' boom logging days of the 1800s.

With the flow diverted to the river's west side, the contractor simply "peeled" the dam back to the east side, beginning in the center of the river.

This photo shows the former dam's site after it was demolished. The banks on either side of the river were cleaned up and seeded to beautify the area. The rapids you see in this picture are located just above the old dam, and are created by the remains of old timber and rock cribs. The smaller "rapids" further upstream is caused by pilings from a former railraod trestle.

Project Costs

The City of Big Rapids was fortunate to obtain 100% grant funding to cover the project's estimated $1,524,000 price tag. Funding partners included the Great Lakes Protection Fund; Great Lakes Fishery Trust; MDEQ; National Fish & Wildlife Foundation and the USGS (see next section for more information on funding). Table 1 recaps the budgeted and actual costs incurred on this project. It shows that the final project came in nearly $300,000 under budget. By virtue of the generosity of the dam removal project's grant agencies, some of this surplus will be applied to fund Big Rapids' 2002 Riverwalk linear park project.

Table 1

Project Cost Recap: Budgeted & Actual

Cost Item	As-Bid Budget	Actual
Dam demolition	$360,816	$360,816
Other misc. demolition	$25,000	$25,000
Rip-Rap for bank stabilization	$49,470	$21,068
Mobilize and de-mobilize sediment dredging equipment	$125,000	$125,000
Create and restore sediment disposal cells	$46,500	$46,500
Dredge sediments	$430,000	$137,035
Riverbank restoration	$14,000	$14,000
Construction Totals	**$1,050,786**	**$729,419**
Engineering	$104,920	$114,415
USGS / MDEQ study	$269,000	$269,000
Contingencies & Insurance	$99,294	$112,000.00
Project Totals	**$1,524,000**	**$1,224,834**

Funding

By December 1999, Big Rapids and the MDNR wrapped up a five-year-long quest to secure the financing needed to bring the project to fruition.

Big Rapids eventually was successful in cultivating the necessary support at the state level while maintaining a strong local focus for this politically sensitive project. "Funding was without a doubt the weakest link in our plan when this project got underway" said Sharon Hanshue, MDNR Fisheries division's dam removal specialist. "We were fortunate that many supporting foundations saw dam removal projects as the 'next new thing' in environmental restoration—just as Big Rapids was completing the planning, design and permitting steps for this project. It was an amazing convergence of interests and needs."

> ***"Funding was without a doubt the weakest link in our plan when this project got underway."***
>
> ***Sharon Hanshue***
>
> ***MDNR Fisheries Division Dam Specialist***

All told, Big Rapids secured grants to fund 100% of the estimated $1,524,000 cost of the project!

The process of securing this funding was a long and arduous one, however. Before the initial public meeting in February 1996, State Senator Joanne Emmons informed Big Rapids that her efforts to secure monies from MDNR's budget were unsuccessful. To do so would require an appropriation and it was unlikely that one was forthcoming.

One of the original premises of the dam removal venture was that MDNR could help Big Rapids fund the project. In the earlier process of re-licensing other Muskegon River hydroelectric dams, the Federal Energy Regulatory Commission (FERC) required dam owners to establish the *Michigan Habitat Improvement Fund (MHIF)*.

This fund was to distribute almost $800,000 annually to qualifying projects on the Muskegon River. In June 1996 Big Rapids applied for a grant from MHIF to pay for much of the cost of the dam removal project. In September 1997, Big Rapids received notification that it was chosen to receive $819,000 in MHIF funds over a three-year period. In November 1997, Consumers Power contested Big Rapids' award to FERC, claiming that the dam removal project was outside the scope of activities originally intended by the MHIF. FERC ruled in December 1998 in favor of Consumers Power, and the Michigan Attorney General and MDNR subsequently sued Consumers Power (unsuccessfully) to reinstate the funding.

In November 1996, MDNR attempted, unsuccessfully, to create state-wide legislation to establish an $11,000,000 fund to facilitate both Big Rapids' and other communities' dam removals.

By July, 1998 MDEQ was able to set aside $100,000 from their annual budget for a grant to fund the Big Rapids dam removal project, and at the same time Big Rapids matched MDNR's $12,000 to fund the completion of dam removal plans and specifications.

In February, 1999 Big Rapids received its first check--$100,000 from the National Fish & Wildlife Foundation.

Then, in June of 1999, MDEQ set aside another $100,000 grant for the project, while USGS committed a total of $119,000 in Water Resources Cooperative funds. These funds helped pay for a proposed

study of the dam removal's effects on the Muskegon River before, during and after the project.

In September 1999, the Great Lakes Protection Fund stepped forward with a $755,000 grant commitment to the project.

Finally, in November 1999 the Great Lakes Fishery Trust capped Big Rapids' $1,524,000 funding package with a $350,000 grant.

Big Rapids Dam Removal

Funding Partners

Great Lakes Fishery Trust $350,000

Great Lakes Protection Fund $755,000

MDEQ $200,000

USGS $119,000

U.S. Fish & Wildlife Foundation $100,000

Here are some of the many wooden timbers taken from the dam. They were part of the original 1866 dam.

Technology Transfer

The Big Rapids Dam Removal project is of great value to both the engineering profession and that of environmental science. It is important first because of its method of sediment management. The innovative method conceived by Prein&Newhof and The King Company showed that it is possible to perform a dam removal while managing the mobilization of sediment that could potentially cause environmental damage and flooding. This project helped foster a national consciousness of the key role of sediment management for dam removals, as few previous dam removal projects have considered sediment mobilization a major issue.

Its national exposure in engineering and environmental news coverage shows just what an influence this project has had and will continue to have. Because of its unusual and ground-breaking nature (particularly for its comprehensive sediment management approach), this project was featured in several national and regional publications, including:

- *Engineering News-Record*; August 28, 2000
- *CE News;* October 2000
- *Civil Engineering Magazine*; December 2000
- *Michigan Out-of-Doors Magazine*; May 2001
- *Michigan Riparian Magazine*; November 2000
- *Pipeline Magazine*; 4th Quarter 2000
- *Shoreline Business Monthly*; October 2000
- *Michigan Professional Engineer Magazine*; Nov./Dec. 2000
- *Great Lakes Reporter,* MIChapter-APWA; 4th Quarter 2001
- *Construction Association of Michigan Magazine*; March 2001

The project also has technical value in the environmental science arena. The USGS[4] and MDNR Fisheries Division continue to document and evaluate the effects of this project on sediment movement and the river's ecosystem before, during, and after dam removal.

The USGS and MDNR study is using a multi-disciplined approach that includes the collection of water-quality and sediment samples, monitoring of stream flow and physical properties, measurements of river profiles, and habitat assessments of selected river reaches. The study began in December 1999 with the establishment of a stream flow gaging station and will continue through September 2002.

The study reach extends from White's Bridge (two miles upstream of the dam) in White Pine Trail State Park downstream to where the Muskegon River intersects the dividing line between sections 23 and 24 of Big Rapids Township. This section dividing line coincides with the upstream limit of the Rogers Dam impoundment as designated by the Federal Energy Regulatory Commission. A stream flow gaging station is located at the Big Rapids sewage treatment plant downstream of the dam toward the middle of the study reach. Data from this station is used to calculate sediment loads. Also located at the station are a continuous water-quality monitor and two automatic suspended-sediment samplers. The continuous water-quality monitor records hourly readings of water temperature, specific conductance, and dissolved oxygen concentrations. One automatic suspended-sediment sampler collects a daily sample, whereas the other sampler is set to trigger during storm events to collect additional samples.

USGS scientists sample sediments from the Maple Street (M-20) bridge.

Water-quality, suspended-sediment, and bed-load samples are collected from White's Bridge and the M-20 Bridge (downstream of the dam) above the sewage treatment plant. The White's Bridge samples are used to establish a water-quality base line and to estimate the sediment load entering the study reach. The M-20 bridge samples are used to assess changes in water-quality and sediment load within the reach containing the dam remnant. The M-20 sediment samples are also used to calibrate the continuous suspended-sediment monitors.

Thirty-nine river transect stations have been established within the study reach to track changes in stream bottom and gradient. Seventeen of the transect stations are located within five habitat assessment reaches. Habitat assessments consist of both the habitat assessment portion of the MDNR Great Lakes and Environmental Assessment Section (GLEAS 51) (Michigan Department of Natural Resources, 1991) and the USGS National Water Quality Assessment (NAWQA) transect procedure.

From an analysis of the water-quality samples collected at White's Bridge and the M-20 Bridge prior to the dam remnant removal, the dam remnant appeared to have no discernable effect upon water quality in the river. The reservoir behind the dam remnant allowed run-of-the-river flow with a relatively small storage capacity and short residence time.

It is unknown at this time whether this is a result of the dam removal or normal sediment movement through the river system. Preliminary examination of the post-dam-removal habitat assessments finds one area upstream of the dam remnant has had a dramatic improvement in habitat quality since the dam remnant removal, whereas three downstream transects have shown slight habitat degradation.

River-bottom transects were made prior to the dam remnant removal (prior), a few months after the removal (short-term), and one year later (one-year). This last set was made after the removal of the rock cofferdam in 2001. Two areas upstream of the dam remnant show erosion of sediments. One upstream area shows the annual deposition and erosion of sediments near the upstream end of the backwater from the dam remnant and that some erosion has occurred in this area since the dam remnant was removed. Immediately downstream, no erosional effects have been observed. The area upstream of the dam remnant has undergone significant removal of sediment. Some of this sediment was dredged during the dam remnant removal, the remainder was remobilized to be captured by the secondary sediment trap or to be transported down the river.

Downstream of the dam remnant, sediment deposition varies with the reach. At the first transect downstream of the sediment trap, there is little difference in the prior and short-term profiles. The one-year profile, however, shows substantial deposition in the deep channel there. Further downstream, there is little evidence of sediment deposition from the profiles. Here, the Muskegon River flows in a high-gradient reach with increased velocities. Farther downstream near the Big Rapids City limits, the one-year profile

For the study, the river bottom profile was checked before, during and after the dam removal to determine the sediment movement pattern.

The sediment management process used on this project will serve as a model for future projects.

shows deposition over the entire channel with the deeper sections completely filled in.

Updates on the USGS/MDNR study can be seen at the USGS' project web site:
http://mi.water.usgs.gov/splan5/sp09500/bgassess.php#prelim

It is further evidence of the project's value to the state-of-the-art of engineering related to dam removals that its entire $1,524.000 budget was funded through grants from five separate agencies, largely on the basis of the knowledge that could be gained from the project. For example, this booklet is being produced as a technology transfer tool with funds provided by the Great Lakes Fishery Trust. In addition, both Prein&Newhof and Big Rapids representatives have delivered a number of presentations featuring this project to several state and regional audiences.

Surprises

There were relatively few surprises encountered during this project. The most significant visual surprise was the discovery of several timber and rock cribs near the middle of the river that became exposed as the river's level was drawn down. These cribs have been left in the river. It is expected that

In the 1800s, loggers used timber and rock cribs to corral logs in the river. This formerly inundated old timber and rock crib caused the river's flow to erode a nearby bank.

Once the dam's impoundment was drawn down over four feet, many interesting relics became exposed. Just above the dam, the remains of the former steel superstructure for a railroad bridge was found embedded in sediment. The contractor removed the steel and disposed of it.

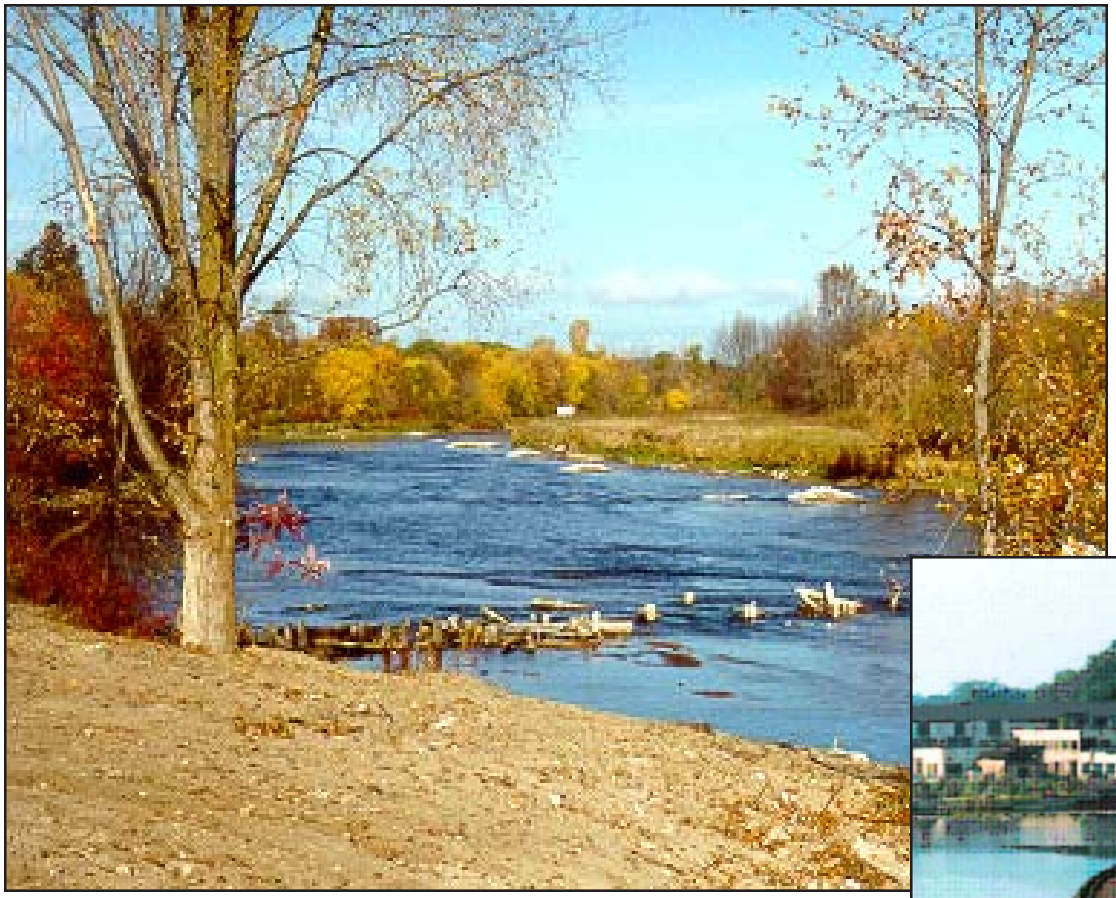
the timber will gradually decay, and the rock inside the cribs will fall to the river bottom. Ice is also expected to assist in the process of "naturally" demolishing the cribs.

The project team knew from historical photos that a railroad trestle crossed the impoundment just upstream of the dam remnant's impoundment. While one of the contractor's bid items was to remove the remnants of the trestle from the river's flow channel, he did not anticipate finding 140 wooden pilings still in the river! The contractor also discovered the remains of the trestle's former steel superstructure on the river bottom. It evidently was stripped from the trestle foundation and "dumped" into the river. By the time it was discovered, its twisted remains had become part of a large sand bar. The contractor was paid to cut the steel beams out of the sand bar, and haul all of the steel off-site.

It was interesting to discover as much intact earthen fill within the dam's structure as was found. When demolishing the dam, the biggest concern was for river-bottom sediment to flow downstream. Ironically, the earthen dam fill was released into the river and remained suspended beyond the project area. The sand moved as expected: like lava down a mountainside. Fortunately, the "muddy" river was short-lived, and the City fielded no complaints.

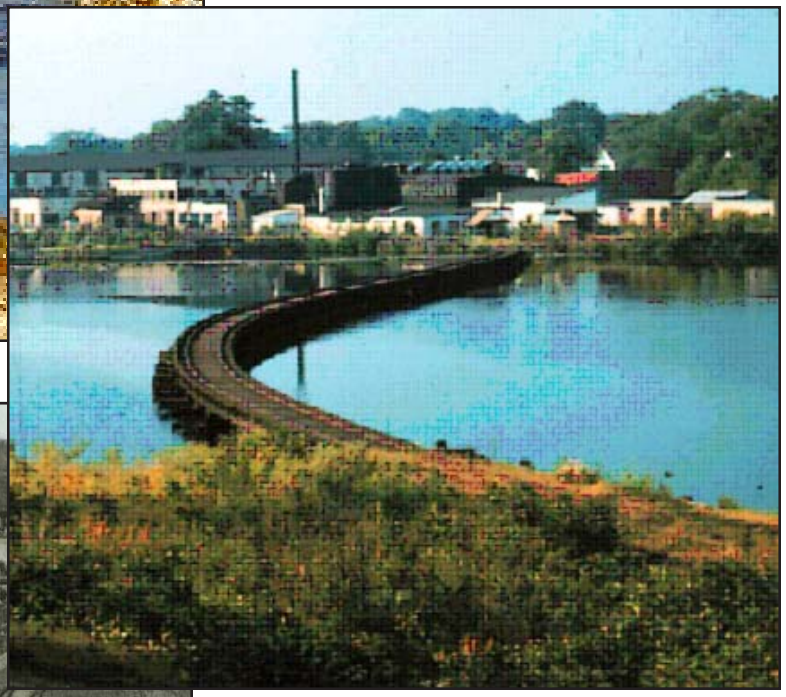
Finally, there were hundreds of old timbers lining the river banks. While their existence was known during design, the number of timbers exposed during the drawdown was indeed a surprise. These timbers served a valuable erosion and sediment control function, in that they tended not to mobilize during the drawdown. They remained behind and either trapped sediment or protected the river's former banks from sloughing into the river's flow.

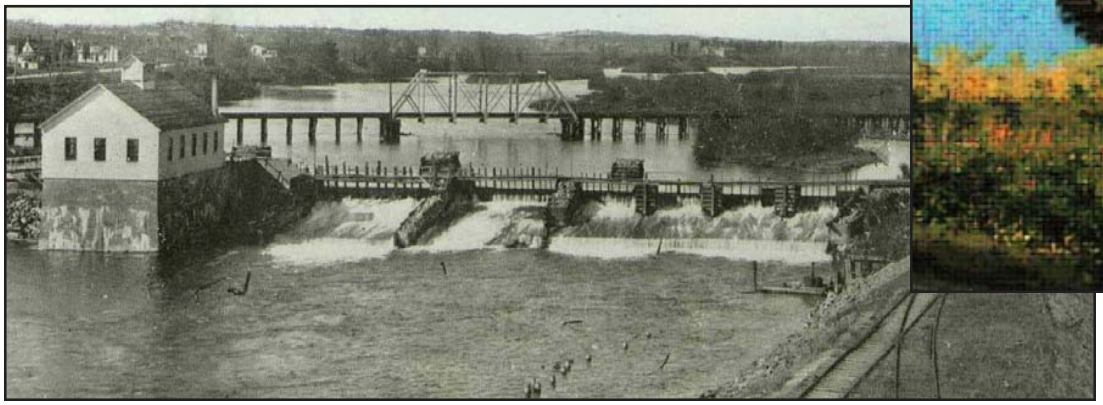
Old logs lined the river's banks and actually helped to prevent bank erosion when the water level dropped. The logs shown above and below settled on a sand bar. The green grass was planted along the bank by the contractor to reduce future erosion.



A railroad trestle once crossed the Muskegon river immediately above the dam. Here you can see the timber pilings from the trestle emerging from the water. These piles were removed by the contractor.

The below-left photo shows the original trestle's superstructure. Below right, the same crossing without the superstructure. Apparently, the superstructure was removed and dumped into the former impoundment.





Lessons Learned

Big Rapids became proud owners of their dam for $6,000. Other communities have taken possession of their dams for as little as $1.00! Ownership of a dam carries with it serious responsibilities, many of which are financial or liability-related. Before buying a dam, take a moment to learn what you are getting into!

Managing sediment on this project was extremely expensive. In total, less than 20,000 cubic yards of sand was extracted from the river at a cost of over $300,000. The controlled drawdown process worked extremely well in minimizing the amount of sediment that mobilized. Because of the sensitive nature of sediment mobilization on this project, it was necessary to take extraordinary measures to contain it. For most future dam removals, it would be much more cost-effective and even environmentally reasonable to simply use a controlled drawdown process while allowing mobilized sediments to settle to the river bottom.

Funding this project required perseverance, contacts, presentations, more perseverance, a unique monitoring process and a challenging project that could contribute to the scientific body of knowledge relating to dam removals. The funding for this project was committed largely on the knowledge and technology transfer that could be gained from this "life-sized" laboratory. Dam removals will remain expensive and outside of the budget of most municipalities, even with the scaled-back sediment management approach recommended above. Funding future dam removal projects will remain difficult until there are significant grant funds available from the public and private sectors to do so.

The most wonderful lesson learned from this project was its impact on the community. The public input process leading up to the dam removal focused almost entirely on "what could go wrong." The design team and the City placed so much focus on avoidance of negative results, that it was not until the "big rapids" revealed itself that much thought was given to ways to exploit the river's beauty. Subsequently, a private local group named "Access for All" raised over $250,000 as seed money for the City to develop what is now known as "Riverwalk," a one-mile long, fully-grant funded, $1,000,000 linear park and pathway that follows the Muskegon River through the Big Rapids City limits. Riverwalk construction began in 2002, and the Big Rapids community is very excited for its opening in summer 2003.

This project also was very fortunate in that the property inundated by the dam remnant's impoundment was owned largely by the City. This made dealing with the upstream effects of removing the dam very easy and un-contentious. Most dams impound water on private land, and it would not be so simple to gain acceptance.

Finally, the City "lucked out" in that two of the finest and most experienced contractors in Michigan teamed up to remove the dam. The King Company and Pitsch Companies had worked together successfully on other dam removals and marine demolition projects. The project team actually spent a great deal of time with representatives of each company in formulating the removal plan. As was apparent from the unsuccessful 1966 removal attempt, the right contractor makes a world of difference. If you are contemplating removing a dam, it is recommended that potential contractors be pre-qualified whether you go through a bidding or negotiation process.

Results

Ultimately, the project team's ingenuity and perseverance resulted in success.

Both City officials and the community are overjoyed with the outcome of the project. What could have been a disaster, with the potential for more sediment mobilizing and causing flooding, turned out to be a benefit for the entire community. The City of Big Rapids accomplished its primary purpose: to improve the quality of life for the community. The Muskegon River is now a safe place for fun and recreation and this project has improved the environment for visitors, citizens, and the fish and wildlife that depend on the river.

Big Rapids Mayor Edward Burch, P.E. and City Manager Steve Stilwell wrote in a letter to Prein&Newhof's project manager, Jim Hegarty, P.E.: "The project was completed on time and drastically under budget, all made possible by the inventive efforts of Prein&Newhof."

The restored Muskegon River is a source of pride for all those involved with this project, and the community has shown its overwhelming support by developing plans for the $1,000,000 Riverwalk adjacent to the former dam remnant's location. With the consent of one of the project's major funding partners, $200,000 of the money that the City saved on the dam removal project has now been contributed to Riverwalk's development.

Big Rapids' Recreation Master Plan calls for increasing the public's awareness and use of the Muskegon River, and both the dam removal and the Riverwalk fulfill the City's vision. Over $250,000 of the Riverwalk's project's cost were raised by a local citizens' group called *Access for All*. Riverwalk will provide the community and visitors with a scenic path along the river, with handicapped access. It is scheduled to be built in 2002 and 2003.

By the autumn of 2001, the Muskegon River in Big Rapids had a new 'look.' The big rapids were back! Several timber and rock cribs, used in the 1800s to 'corral' lumber as it floated to local sawmills, became visible as the river's level dropped behind the dam.

The Big Rapids dam removal has placed the City on the "environmental" map, developed a recreational capacity never before envisioned, and restored beauty last seen well over 100 years ago.

Environmentalists herald this project to remove the remains of the 1912-vintage hydroelectric dam from Michigan's second-longest river as a national model for sediment management on similar projects.

Now, the Muskegon River drops almost nine feet in elevation in less than a mile. This certainly restores the big rapids in Big Rapids. One might think Chief Seattle would be proud of the City of Big Rapids and its efforts to come "full-circle" by helping to restore the Muskegon River to its natural grandeur. The community may now look at the river as their ancestors did 130 years ago.

Meanwhile, USGS and MDNR scientists will continue to study the effects of this project on water quality, fish populations and benthic organisms within the dam remnant's former influence area. These studies will eventually document the impact of this project on the Muskegon River's ecosystem.

Awards

The Big Rapids Dam Removal project has received awards from the following organizations:

- The Michigan Chapter of the American Public Works Association honored the Big Rapids Dam Removal project as one of its Public Works Projects of the Year at its 2001 annual meeting.
- The Michigan Section of the American Consulting Engineers Council and the Michigan Society of Professional Engineers selected this project for a Merit Award at the 2002 Engineering Excellence Awards Competition.
- The Great Lakes Fishery Trust named this project its Grant Project of the Year in 2001.
- The Michigan Municipal League honored Big Rapids with its Outstanding Achievement Award in 2002.

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